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Invention: METHOD OF SENDING TIME SLOTS IN BASE STATION SYSTEM AND SUCH A SYSTEM

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SPECIFICATION

7/PRTS

METHOD OF SENDING TIME SLOTS IN BASE STATION SYSTEM AND SUCH A SYSTEM

FIELD OF THE INVENTION

The invention relates to a method of transmitting time slots in a base station system.

BACKGROUND OF THE INVENTION

Time slots are transmitted as a radio signal to a receiver's subscriber terminal over a radio path via a base station system of a cellular radio network. International standardization authorities, for instance the European Telecommunications Standards Institute ETSI, have defined the specifications a base station system should use. The specifications cover, for example, transceivers of a base station included in a base station system. Power consumption, operating life, average time between faults, operating temperatures, etc., for example, have been specified for the transceivers.

A vast majority of time slots are usually transmitted at a normal transmission power. A normal transmission power refers to a predetermined power range. A subscriber terminal can direct a base station to increase or decrease the transmission power used based on estimations of the reception power. Power control aims to optimize the ratio between radio transmission quality and interference caused by the radio transmission to other users. Usually, the aim is sufficiently high quality with the lowest possible interference.

Certain time slots, for example a time slot comprising a control channel, can be transmitted at a constant power higher than a normal transmission power. The power must be constant so that the subscriber terminal can perform measurements of a neighboring base station enabling handover. The power is higher than normal in order to enable the control channels to be better received. Also other special channels, for example time slots comprising packet switched data or circuit switched data, can be transmitted at a power higher than normal in order to achieve better coverage. In the General Packet Radio Service GPRS of the GSM, for example, light or even non-existent convolution coding is used for channel coding, in which case the transmission power has to be higher in order to guarantee the transmission to reach its destination. In the Enhanced Data Rates for GSM Evolution EDGE of the GSM, a Phase Shift Keying 8-PSK selected as the modulation method also requires a better signal-to-noise ratio than a normal GSM modulation method.

A way to improve the signal-to-noise ratio is to use a transmission power higher than normal.

When transmission powers higher than normal are used, it becomes problematic to meet the specifications defined for the base station. This is due to the fact that transmission powers higher than normal cause power consumption higher than normal in the base station; consequently, power sources higher than normal are needed, and, similarly, more extensive back-up batteries also become necessary. When transmission powers higher than normal are used, transceivers also become increasingly heated, which means that more efficient fans are needed. It becomes more difficult to design a radio network because a base station using transmission powers higher than normal is larger than normally, requiring larger power sources. Transceivers using transmission powers higher than normal also suffer more easily from failures owing to the fact that their components become more easily overheated than normally.

It has been estimated that the material and operating costs of a base station increase by as much as 30% when transmission powers twice as high as normal are used. This is due to costlier transceivers, larger power sources, more extensive back-up batteries, more efficient cooling systems, higher renting costs of a base station location, etc.

If the power consumption of a base station could be reduced by half when using transmission powers higher than normal, the base station running temperature would decrease significantly, in which case its operating life could even double or quadruple.

A solution to the heating problem described above is to use a "combiner bypass" structure in the base station. In such a case, time slots usually requiring transmission power higher than normal, time slots comprising control channels, for example, are then bypassed past a combiner since considerable power losses of several decibels take place in the combiner when signals are combined. For instance, when four transceivers using a 10-watt transmission power are combined in the combiner, only a 2.5-watt input transmission power can be generated to an antenna per one transceiver, resulting in a power loss of approximately 6 decibels. The signals directed past the combiner are conveyed to a separate antenna via which the signals are transmitted. Consequently, the time slots usually requiring transmission power higher than normal can now be transmitted at a normal transmission power

since no power loss takes place thanks to the combiner. Because the number of antennas usually is a determining factor for the renting costs of a base station location, the required additional antenna presents the most serious problem of this solution. In a normal base station divided in three sectors the described solution necessitates three additional antennas. Furthermore, the additional antennas cause the wind load of the a mast structure to increase, which means that the mast structure has to be built stronger and, consequently, costlier.

BRIEF DESCRIPTION OF THE INVENTION

An object of the invention is thus to provide a method and an apparatus implementing the method such that the above-mentioned problems can be solved. This is achieved with a method of transmitting time slots in a base station system, the method comprising the steps of: defining certain transmission powers as a normal transmission power; determining for each time slot the transmission power to be used. In accordance with the invention, the method is characterized by transmitting time slots to be transmitted at a transmission power higher than normal alternately, using at least two different transceivers in order to minimize heat build-up in the transceivers.

The invention further relates to a base station system comprising: at least two transceivers; a control part for controlling the operation of the transceivers; a switching field for connecting time slots to the transceivers; certain transmission powers being defined as a normal transmission power in the control part; the control part being arranged to determine for each time slot a transmission power to be used. The base station of the invention is characterized in that the control part is arranged to direct the switching field to place time slots to be transmitted at a transmission power higher than normal to be transmitted alternately, using two different transceivers in order to minimize heat build-up in the transceivers.

The preferred embodiments of the invention are disclosed in the dependent claims.

The idea underlying the invention is that time slots requiring transmission powers higher than normal are not continually transmitted via the same transceiver but alternately via different transceivers.

The method and system of the invention provide several advantages. Heat build-up in a single transceiver can be minimized, whereby the

above-described problems presented by the heating of the transceiver can be avoided. The transceiver and its power generation and cooling systems can be designed for lower power.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is now described in closer detail in connection with the preferred embodiments with reference to the accompanying drawings, in which

Figure 1 shows an example of the structure of a cellular radio network,

Figure 2 shows the structure of a transceiver,

Figure 3 shows a circuit-switched telephone connection,

Figure 4 shows packet transmission,

Figure 5A illustrates the operation of a combiner,

Figure 5B illustrates transceivers using different antennas,

Figure 6 shows an example of time slot allocation of the invention to different transceivers,

Figure 7 is a flow diagram of the method steps of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The invention can be used in a cellular radio network wherein a signal to be transmitted can be divided into subsignals in the time domain. Referring to Figure 1, a typical structure of a cellular radio network is described. Figure 1 comprises only relevant blocks for describing the invention, but it is obvious to those skilled in the art that a common cellular radio network also comprises other functions and structures which need not be described here. The examples describe a cellular radio network using Time Division Multiple Access TDMA without, however, being restricted thereto.

A cellular radio network typically comprises a fixed network infrastructure, i.e. a network part 128, and subscriber terminals 150, which can be fixedly located, positioned in a vehicle or portable terminals to be carried around. The network part 128 comprises base stations 100. A plurality of base stations 100, in turn, is controlled in a centralized manner by a base station controller 102 connected thereto. The base station 100 comprises transceivers 114. A base station 100 typically comprises 1 to 16 transceivers 114. In the TDMA radio system, for example, one transceiver 114 typically provides one TDMA frame, i.e. 8 time slots, with radio capacity.

The base station 100 comprises a control unit 118 controlling the operation of the transceivers 114 and a multiplexer 116. The multiplexer 116 is used for placing traffic channels and control channels used by the plurality of transceivers 114 over one transmission connection 160.

The transceivers 114 of the base station 100 are connected to an antenna array 112, which implements a bidirectional radio connection 170 to the subscriber terminal 150. In the bidirectional radio connection 170, the structure of frames to be transferred is clearly defined, and it is called an air interface.

Figure 2 shows the structure of one transceiver 114 in closer detail. First, functions during reception are described. A receiver 200 comprises a filter blocking frequencies outside a desired frequency band. Next, the signal is converted to an intermediate frequency or directly to baseband, and the signal in this form is sampled and quantisized in an analogue/digital converter 202.

An equalizer 204 compensates for interference caused by multi-path propagation, for example. A demodulator 206 draws a bit stream from the equalized signal, the bit stream being conveyed to a demultiplexer 208. The demultiplexer 208 separates a desired part of the bit stream into logical channels. This function is based on the structure of the received bit stream which consists of radio bursts placed in the time slots, the radio bursts forming the physical channel.

A channel codec 216 decodes the bit stream of different logical channels, in other words decides whether the bit stream is signalling information, which is relayed to a control unit 214, or whether the bit stream is speech, which is relayed 240 to a speech codec 122 of the base station controller 102. The channel codec 216 decodes potential channel codings, for example block coding and convolution coding, and deinterleaves potential interleaving, and decrypts the encryption used over a radio path.

The control unit 214 performs internal control tasks by controlling the different units, mainly according to commands received from the base station controller 102.

Next, functions during transmission are described. Data to be transmitted is channel-coded, interleaved and encrypted in the channel codec 216. A burst generator 228 adds a training sequence and a tail to the data supplied from the channel codec 216. A multiplexer 226 indicates the physical channel to each burst. A modulator 224 modulates the digital signals into a

radio frequency carrier wave. Being analogue by nature, this function requires a digital/analogue converter 222.

A transmitter 220 comprises a filter to restrict the bandwidth. In addition, the transmitter 220 controls the output power of the transmission. A synthesizer 212 provides the different units with necessary frequencies. A clock comprised by the synthesizer 212 can be locally controlled or it can be controlled in a centralized manner from somewhere else, for example from the base station controller 102. The synthesizer 212 creates the necessary frequencies by a voltage-controlled oscillator, for example.

In the manner shown in Figure 2, the structure of the transceiver can be further divided into radio frequency parts 230 and a digital signal processor with its software 232. The radio frequency parts 230 comprise the receiver 200, the transmitter 220 and the synthesizer 212. The digital signal processor with its software 232 comprises the equalizer 204, the demodulator 206, the demultiplexer 208, the channel codec 216, the control unit 214, the burst generator 228, the multiplexer 226 and the modulator 224. Converting an analogue radio signal into a digital signal requires the analogue/digital converter 202, and, correspondingly, converting a digital signal into an analogue signal requires the digital/analogue converter 222.

The structure of the subscriber terminal 150 can be represented by utilizing the depiction of the structure of the transceiver 114 in Figure 2. The structural parts of the subscriber terminal 150 are operatively similar to those of the transceiver 114. The subscriber terminal 150 further comprises a duplex filter between the antenna 112 and the receiver 200 and the transmitter 220, the user interface parts and the speech codec. The speech codec is connected to the channel codec 216 via the bus 240.

If the base station 100 employs frequency hopping, it can be implemented in two ways: as base band hopping or synthesizer hopping. If the base station 100 comprises a plurality of transceivers 114, each time slot is transferred to a transceiver 114 operating at a certain base band in accordance with a frequency hopping sequence. If, for example, the base station comprises only one transceiver 114 and frequency hopping is to be implemented, a synthesizer 412 and a transmitter 420 must then be directed to different frequencies in order to transmit each time slot at a frequency according to the frequency hopping sequence.

The base station controller 102 comprises a group switching field 120 and a control unit 124. The group switching field 120 is used for switching speech and data, and for connecting signalling circuits. A base station system 126 comprises the base station 100 and the base station controller 102 further comprises the transcoder 122. Task assignment between the base station controller 102 and the base station 100 and the physical structure thereof may vary according to the implementation. The base station 100 typically serves to implement the radio path in a manner described above. The base station controller 102 typically manages the following tasks: traffic channel configuration, frequency hopping control, subscriber terminal paging, power adjustment, active channel quality control and handover control.

The transcoder 122 is usually located as close to a mobile services switching centre 132 as possible since speech can thus be transmitted in the cellular radio form between the transcoder 122 and the base station controller 102 using as little transmission capacity as possible. The transcoder 122 converts the different digital speech coding forms used between a public telephone network and a radio telephone network into compatible ones with each other, for example from the 64 kbit/s form of the fixed network into another form (for example 13 kbit/s) of the cellular radio network, and vice versa. The control unit 124 performs call control, mobility management, collection of statistical information and signalling.

In the cellular radio network, a packet switched connection can also be used, for example the 2+ phase packet transmission of the GSM system, i.e. General Packet Radio Service GPRS.

As can be seen from Figure 1, the group switching field 120 can be used for providing connections (depicted by black dots) to a Public Switched Telephone Network PSTN 134 via the mobile services switching centre 132 and to a packet transmission network 142. A terminal 136 in the public telephone network 134 is typically a common telephone or an Integrated Services Digital Network ISDN telephone.

Figure 3 shows how a normal circuit-switched telephone connection is set up between the subscriber terminal 150 and the common telephone 136.

Figure 4, in turn, shows how a packet-switched transmission connection is set up. The connection between the packet transmission network 142 and the group switching field 120 is set up by a Serving GPRS Support Node SGSN 140. The support node 140 serves to transfer packets between

the base station system and a Gateway GPRS Support Node GGSN 144, and to keep a record of the subscriber terminal's 150 location in its area.

The gate node 144 connects the public packet transmission network 146 and the packet transmission network 142. The Internet protocol or X.25 protocol can be used on the interface. The gate node 144 hides, by encapsulating, the inner structure of the packet transmission network 142 from the public packet transmission network 146, so the public packet transmission network 146 regards the packet transmission network 142 as a subnetwork, and the public packet transmission network can direct packets to and receive packets from the subscriber terminal 150 located in the packet transmission network 142.

Typically, the packet transmission network 142 is a private network using the Internet protocol and conveying signalling and tunnelled user data. The structure of the network 142 may vary in its architecture and protocols according to the operator below the Internet protocol layer.

The public packet transmission network 146 can be the global Internet network, for example. A terminal 148, a server computer, for example, connected to the Internet network is to transfer packets to the subscriber terminal 150.

On the air interface 170, time slots free from packet switched transmission are used for packet transmission. The capacity for packet transmission is allocated dynamically, in other words when a data transmission request is received, any free channel can be allocated to packet transmission. The arrangement is flexible by nature, circuit-switched connections taking priority over packet-switched connections. When necessary, circuit-switched transmission overrides packet-switched transmission, i.e. a time slot used by packet transmission is allocated to circuit-switched transmission. This is feasible since packet transmission is highly tolerant of such interruptions: the transmission is simply continued by another allocated time slot. The arrangement can also be implemented such that no strict priority is given to circuit-switched transmission but both circuit-switched and packet-switched transmission requests are served in order of reception.

Figure 5A discloses the structure of the base station 100 in closer detail. Time slots used by several different transceivers 114 are thus multiplexed to the same transmission connection at the multiplexer 116. The multiplexer 116 also demultiplexes the time slots. In Figure 5A, two transceivers

114 are divided into their logical parts: a transmitter 500A, 500B and a receiver 506A, 506B. A combiner 502 combines signals of the two different transmitters 500A, 500B to be transmitted via one antenna 112. If the transmission power of the transmitters 500A, 500B is ten watts, for example, after the combiner 502 the power to be conveyed to the antenna is approximately five watts, in other words the power loss in the combiner 502 is approximately three decibels. In addition, a duplex filter 504 is required to separate transmission frequencies from reception frequencies. Correspondingly, a divider 508 is provided on the receiving side to separate signals belonging to the different receivers 506A, 506B from each other.

Figure 5B shows a solution which does not use any combiner 502 at all but the transmitters 500A, 500B have a direct connection to separate antennas 112A, 112B, in which case power loss in the combiner 502 can be avoided.

After having thus described an example of a cellular radio network and its operation with reference to Figures 1, 2, 3, 4, 5A and 5B, a method in accordance with the invention can now be examined with reference to Figure 7. The performance of the method of the invention starts in block 700 and ends in block 708.

In the first actual step 702, certain transmission powers are defined as a normal transmission power. This can be a particular power range, for example, or transmission powers listed from graded transmission powers.

In the second actual step 704, for each time slot a transmission power to be used is determined.

In the third actual step 706, time slots to be transmitted at a transmission power higher than normal are transmitted alternately, using at least two different transceivers in order to minimize heat build-up in the transceivers.

A time slot requiring a transmission power higher than normal can be, for example, a time slot in which is placed a control channel, a packet-switched channel (for example a packet data traffic channel of the GPRS), or a high-speed data channel (for example an EDGE-modulated traffic channel or an EDGE-modulated packet data traffic channel of the GPRS).

In a preferred embodiment, the time slots to be transmitted at a higher transmission power than normal are transmitted alternately, using at least two different antennas, thereby providing the transmission with antenna diversity.

In another preferred embodiment of the invention, time slots to be transmitted at a normal transmission power are transmitted using frequency hopping. This compensates for coverage, i.e. nearly as good coverage is obtained for the frequency-hopping time slots transmitted at a normal transmission power as the time slots transmitted at a higher transmission power than normal have.

Figure 6 illustrates the operation in accordance with step 706. In the example of Figure 6, the base station 100 uses four transceivers 500A, 500B, 500C, 500D. One frame 600A, 600B, 600C, 600D comprising eight time slots 0, 1, 2, 3, 4, 5, 6 and 7 can be transmitted via each transmitter 500A, 500B, 500C, 500D.

A channel is composed of a frequency/time slot combination; therefore, all time slots of the first frame 600A are transmitted at a frequency f1, all time slots of the second frame 600B at a frequency f2, all time slots of the third frame 600C at a frequency f3, and all time slots of the fourth frame at a frequency f4. All time slots 0 to 7 of the first frame 600A are time slots requiring transmission power higher than normal. Normally, without the present invention, said time slots would all be transmitted via the transmitter 500A, which would overheat owing to increased heat build-up.

This is avoided by the method of the invention according to which method time slot 0 of the first frame 600A is transmitted at the frequency f1 by the fourth transmitter 500D, time slot 1 at the frequency f1 by the third transmitter 500C, time slot 2 at the frequency f1 by the second transmitter 500B, time slot 3 at the frequency f1 by the first transmitter 500A, time slot 4 at the frequency f1 by the fourth transmitter 500D, time slot 5 at the frequency f1 by the third transmitter 500C, time slot 6 at the frequency f1 by the second transmitter 500B, and time slot 7 at the frequency f1 by the first transmitter 500A. Hence, heat build-up of the time slots transmitted at a higher transmission power than normal is evenly distributed among the different transceivers, in which case no overheating occurs.

The example above only discloses one possibility out of many to distribute heat build-up among different transmitters. The alternation can be carried out in the described manner for each time slot, or, the time slot can be alternated when a certain number of time slots has been transmitted at a transmission power higher than normal via one transceiver. The alternation can also be carried out frame by frame, for example. It is essential that the

transmission of the time slots requiring transmission power higher than normal is alternated between different transceivers. The transceiver can thus be prevented from becoming overheated.

In the example of Figure 6, those time slots that are transmitted at a normal transmission power - in the place of which are transmitted time slots of the first time slot 600A, i.e. time slots 2 and 6 of the second frame 600B at a frequency f2, time slots 1 and 5 of the third frame 600C at a frequency f3, and time slots 0 and 4 of the fourth time slot 600D at a frequency f4 - are transmitted using the free capacity of the first transmitter 500A, i.e. the time slots 0, 1, 2, 3, 4, 5 and 6. This is a possibility to implement the alternation. Another possibility is not to transmit those time slots at all, but this would result in losing the capacity.

The invention can be implemented such that the base station system 126 comprises at least two transceivers 114, the control part 118, 124 for controlling the operation of the transceiver 114, and the switching field 120 for connecting the time slots to the transceivers 114. The control part 118, 124 defines certain transmission powers as a normal transmission power, and the control part 118, 124 is arranged to determine for each time slot the transmission power to be used. Furthermore, the control part 118, 124 is arranged to direct the switching field 120 to place the time slots transmitted at a transmission power higher than normal to be transmitted alternately, using at least two different transceivers 114 in order to minimize heat build-up in the transceivers 114.

A further requirement for the invention is that the transceiver 114 can be directed to a desired frequency applying the same principle described above in connection with synthesizer hopping, in other words it is required that the synthesizer 412 and the transmitter 420 can be directed to different frequencies in order to transmit each time slot at the desired frequency.

The invention is preferably implemented by software, whereby the invention requires functions in the software located in the control unit 124 of the base station controller 102, in the software located in the control unit 118 of the base station 100, and possibly also in the software located in the control unit 214 of the single transceiver 114.

Although the invention has been described above with reference to the example in accordance with the accompanying drawings, it is obvious that

the invention is not restricted thereto but it can be modified in many ways within the scope of the inventive idea disclosed in the attached claims.